The Romanian Research-Development System - An Overview in Global Context

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Abstract: Research, development and innovation play an important role in ensuring sustainable economic growth. By producing new knowledge, research is essential to the development of new and innovative products, processes and services that contribute to increased productivity, industrial competitiveness and ultimately prosperity. For this reason, the encouragement of the research-development and innovation activities has become now an extremely important imperative of the modern socio-economic and technological policies in developed and less developed countries.

The main objective of the present paper is to highlight Romania's performance in the field while presenting the strengths and weaknesses of the national RDI system. In order to achieve the proposed objective, our methodology uses both descriptive and explanatory research. Our research methodology includes a comparative analysis based on Global Innovation Index and other indexes (mentioned in the paper). The analysis of the Global Innovation Index shows that the existing research-development-innovation system in Romania is not able to ensure overcoming the condition of being an emerging innovator, due to some of its weaknesses. Thus, our main finding shows that Romania has untapped potential in the field of RDI, and the current poor performance reflects negatively on the country's competitiveness and long-term growth prospects.

Keywords: innovation, research, development, Romania, innovation performance, research efficiency.

JEL Classification: D80, O10, O30, O39.

1. Introduction

By producing new knowledge, research is essential to the development of new and innovative products, processes and services that enable increased productivity, industrial competitiveness and ultimately prosperity. For this reason, research and innovation plays an important role in generating sustainable economic growth and job creation. Many studies concluded that investing and undertaking effective research and development activities can enhance economic growth (Wang, 2010). Also, Griliches (1995) demonstrates the role of RDI as an important source of growth, in the context of the externalities generated by this activity, and Jones and Williams (1998) state that RDI activities produce significant social effects and constitute an important component of development and growth economic. With the intention of studying the contribution of RDI to economic growth, a study applied to the Australian economy was carried out in 2002. Using data related to the period 1960-2000, the study showed that the constant and long-term economic development at the level of the country was supported by the research undertaken at the local and global level, as well as by the development of innovative ideas (Chou, 2002).

Following the crisis caused by the Covid-19 pandemic, economic growth was, and continues to be, an objective of the government strategies, both at the European and international level. Given that, in the context of the global competitiveness, technological progress is recognized as key element of the sustainable economic development, a central place in this context is occupied by the research, development and innovation sector.

The main objective of the present paper is to highlight Romania's performance in the field while presenting the strengths and weaknesses of the national RDI system. In order to achieve the proposed objective, it was used a combined research methodology using, during the work, both descriptive and explanatory research. Our research methodology includes a comparative analysis based on Global Innovation Index and other indexes

(mentioned in the paper). One limitation of the paper is related to data availability, since in the European database the latest data are at the level of the years 2020-2021.

The importance of the work derives from the fact that research- development-innovation is at the centre of the policies through which the European Commission tries to stimulate employment, economic growth and investments. Horizon 2020, the EU framework program for research-development-innovation (RDI), has strengthened its leadership position in the field of innovation, by promoting excellence in the field of research and development of innovative technologies, in the period 2014-2020 investing 77 billion euros for projects in the field. With a budget of €95.5 billion, Horizon 2020's successor, Horizon Europe, is the EU's main research and innovation funding program for 2021-2027, which aims to: stimulate EU competitiveness and development, strengthen the position of research and innovation in the development, support and implement EU policies, optimize the impact of investments in a European research area. As an EU member, Romania's RDI policy is closely linked to the European one, aiming at joint programming, technological initiatives and pan-European research infrastructures. For the period 2021-2027, the programmatic documents for the RDI sector in Romania are: National Strategy for Research, Innovation and Smart Specialization 2022-2027 and National Plan for Research, Development and Innovation 2022 – 2027 (PNCDI IV).

The Global Innovation Index (GII) report is made by the World Intellectual Property Organization, "Cornell" American University and the French School of Management "INSEAD" and is published annually from 2007 (WIPO,2022). The aim of the Global Innovation Index report is to familiarize interested persons and institutions with all the new aspects in the field of innovations that appear in society and to approach this field beyond traditional innovation mechanisms (Saharnean, 2019). The reasons behind the creation of this report are multiple. Because many governments place innovation at the heart of their economic growth strategies, the first reason is determined by the importance of innovation in driving economic progress and competitiveness – for both developed and developing economies,. The second reason is determined by the expansion of the definition of innovation, which now is not limited to only theoretical research. The Global Innovation Index report adopts a broad definition of innovation, originally introduced in the Oslo Manual developed by the European Communities and Organization for Economic Co-operation and Development (OECD, 2018) - "An innovation is the implementation of a new or significantly improved product (a good or service), or a process, of a new marketing method, or of a new organizational method in business practice, in the organization of workplaces or in external relations" (Maier, 2014). This definition reflects the evolution of the way in which innovation has been perceived and understood in recent decades. Previously, economists and policy makers focused on research, development and product technological innovation, today innovation capacity is seen more as the ability to exploit new technological combinations. According to the Adler and Shenbar (1990) innovation capability is defined as the capacity of: developing new products satisfying market needs, applying appropriate process technologies to produce these new products, developing and adopting new products and processing technologies to satisfy future needs. The last, but not the least, reason is determined by the fact that in emerging markets innovation is a key element in inspiring the next generations of entrepreneurs and innovators.

The GII do not intend to realize a final and definitive ranking of economies in the field of innovation, but aims to improve innovation by measuring it as accurately as possible and by identifying policies, best practices and other levers that encourage innovation. It helps to create an environment where the influencing factors of innovation are under continuous evaluation and provides a key tool and a rich database that can contribute to the development of innovation policies.

Over the past decade, GII has established itself as a leading reference in the field of innovation. Better understanding of the human aspects behind innovation is essential for developing policies that help promote economic development. Recognizing the key role of innovation as a driver of economic growth and prosperity and the need for a broad overview of innovation applicable to developed and emerging economies, the GII includes indicators that go beyond traditional measures of innovation, such as the level of research and development and the amount of investment allocated in innovation (Saharnean, 2019).

The global innovation index is built on the basis of two sub-indices – the input innovation sub-index and the output innovation sub-index. The first targets at the elements that influence innovative activities, such as research and development – while the output innovation sub-index targets at the results of these activities (Cristina, 2020). Each sub-index is divided into pillars; the pillars are divided into sub-pillars while each sub-pillar is composed of individual indicators. The scores for each sub-pillar are calculated as the weighted average of the individual indicators, and the pillar scores are calculated as the weighted average of the sub-pillar scores. The overall global innovation index is calculated as the simple average of the input and output sub-indices. The innovation efficiency ratio is the ratio of the output sub-index to the input sub-index.

The innovation input sub-index is built on the basis of five sub-pillars that assess the factors that enable and favour innovative activities: institutions, human capital and research, infrastructure, market sophistication, business sophistication.

The output sub-index for innovation is built on the basis of two pillars that assess the results of innovative activities within economies - Knowledge and technology outputs, creative outputs. Although it includes only two pillars it has the same weight in calculating the value of the Global Innovation Index as the inputs sub-index (Cristina, 2020).

2. The efficiency of the Romanian research, development and innovation sector

Research in Romania can be categorized as low-performing, under-funded (both from public and private sources) and with a low impact worldwide. The last evaluation of the RDI system in Romania carried out by the European Commission (European Commission, 2022) highlighted more or less the same recurring challenges, including the fragmentation of governance, the focus on fundamental research and the non-use of private potential and, often , improper use of available funds. The report states that" Romania's research sector shows elements of strength, it does not perform as a coherent system. The combination of a fragmented public research sector, lack of financial stability and predictability, fragmented governance, erosion of human capital, weak public-private sector interaction, uneven monitoring and evaluation, and unpredictable political support, form a vicious circle which needs to be broken".

Despite the efforts made in the field of research and development in Romania, there are some weaknesses that directly affect progress and performance in this field. Among them we can mention:

- Insufficient funding: The budget allocated to research and development in Romania is insufficient to support high-quality projects and to attract and retain talented researchers. Lack of adequate financial resources limits the ability of research institutions and universities to carry out innovative research and invest in a modern infrastructure;
- Fragmentation and lack of coordination: Research and development is often fragmented across different institutions and organizations, leading to a lack of coordination and cooperation between them;
- Migration of researchers: Romania is experiencing a significant migration of talented researchers to other countries, where there are more opportunities and better working conditions. This migration directly affects the research and development capacity and leads to the loss of intellectual capital and investment in the training of these specialists;
- Insufficient collaboration between academic environment and industry: Collaboration between universities and industry is often limited in Romania. The lack of a close link between academia and industry leads to a separation between fundamental research and the real needs of industry, which limits technology transfer and innovation in the industrial sector.
- Excessive bureaucracy: Complicated and red tape-laden bureaucratic procedures can hamper the process of financing and implementing research and development projects. This may discourage researchers and institutions from engaging in R&D activities and may affect efficiency.

Despite these weaknesses, the research and development system in Romania has some strengths:

- there are many talented and passionate researchers who achieve results in various scientific fields;
- there are programs and initiatives that encourage young researchers and promote innovation and international collaboration;
- Romania has a good expertise in certain key areas such as IT&C, renewable energy, medicine, biochemistry and agriculture
- Romania collaborates with other countries and international organizations in the field of research and development. There are joint projects, exchanges of experience and funding for frontier research.
- There are programs and initiatives that encourage the involvement and development of researchers. Research grants, fellowships, training programs and academic competitions provide opportunities for researchers to demonstrate their skills and develop their research careers.

Regarding Romania's position in the "Global Innovation Index" and "European Innovation Scoreboard" system of indicators, although some indicators show an improvement, the general trend is a decrease in performance.

The Global Innovation Index 2022 provides a detailed picture of the innovation performance of 132 countries and economies around the world. Its 81 indicators explore a wide area of innovation, including politics, education and business. From year to year the number of innovation performance indicators and the countries participating in the study differed. For example, in 2013 the GII used 84 indicators for the comparative evaluation of the innovation capacities of 142 countries (which included 94.9% of the world's population and constituted 98.7% of the world's GDP). The framework is reviewed every year in a transparent exercise to improve how innovation is measured (Saharnean, 2019).

As can be seen in Table 1 Switzerland and the USA are the innovative leaders of the high-income countries group, occupying the first and second places. Surprisingly, Bulgaria occupies the second place as an innovative leader of the upper middle-income countries group, alongside China and Malaysia, while Romania holds the 8th rank in this group.

Table 1: Innovation leaders by income group according to GII 2022

High-income		**Upper middle-income**		**Lower middle-income**		**Low-income**	
Switzerland	64.6	China	55.9	India	36.6	Rwanda	18.7
USA	61.8	Bulgaria	39.5	Vietnam	34.2	Madagascar	18.6
Sweden	61.6	Malaysia	38.7	Iran	32.9	Ethiopia	16.3

Source: Authors' computations based on the Global Innovation Index 2022

In 2022, Romania occupied the 49th place among the 132 economies included in the GII 2022. It should be noted that the availability of data and the changes made in the GII methodology influence comparisons from one year to another. The statistical confidence interval for Romania's GII 2022 ranking is between 48th and 52nd places. As it can be observed in the Table 2, in 2022 the general position of the Romania descended with one place comparing with 2021 and with three places comparing with 2020. However the position occupied in 2022 was superior to the position occupied in 2019.

Table 2: Romania's position in the Global Innovation Index (2019-2022)

Description	**Position**			
	2019	**2020**	**2021**	**2022**
Innovation input sub-index	53	46	50	56
Innovation output sub-index	54	51	54	43
Global Innovation Index	50	46	48	49

Source: Authors' computations based on the Global Innovation Index 2019-2022

In 2022, Romania obtained better results in terms of innovation outputs than innovation inputs. It ranked 43th place in terms of innovation outputs, occupying a better place comparing with the previous years. In terms of innovation inputs, in 2022 Romania ranked 56th place, this position being lower than the previous years. At the same time, Romania ranks 40th among the 51 economies with high incomes and 31st among the 39 economies in Europe.

Table 3: Romania's position within the GII pillars (2019-2022)

Description	**Position**			
	2019	**2020**	**2021**	**2022**
Institutions	50	53	53	75
Human capital and research	69	76	76	74
Infrastructure	35	37	36	33
Market sophistication	92	83	76	63
Business sophistication	51	53	54	51
Knowledge and technology outputs	41	28	35	31
Creative outputs	71	67	72	57

Source: Authors' computations based on the Global Innovation Index 2019-2022.

The poor performance of the Romanian research system is determined by: the low level of RDI spending, underfunding, the fragmentation of RDI in the public sector and its insufficient orientation towards the needs of the industrial sector, the excessive priority given by some institutes to fundamental research, insufficient number of researchers.

During 2019 -2022 the best positions occupied by Romania are within the pillars Infrastructure and Knowledge and technology outputs. Thus, in the 2022 ranking, within the Knowledge and technology outputs pillar Romania occupied the 31st place (inferior compared to 2021 when it occupied the 34th position, but superior to 2020 when it occupied the 28th position). Within the Infrastructure pillar Romania occupied in 2022 the in 33rd place (superior to the previous years- 2019, 2020, and 2021- when it occupied the 35th, 37th and 36th position). The weakest performance recorded by Romania was registered at human capital and institutions pillar, where it occupied the 74th and 75th place.

Regarding the human capital dimension, it is important to mention that Romania has the lowest number of researchers in the EU 27. As can be seen in table 4, the total research and development staff has decreased substantially since 1993 from over 73,611 to 33,892 in 2000. Since then the number of researchers has stabilized around 30,000, reaching 33,189 in 2020. Demographic changes and the migration of highly skilled labour have led to structural changes in R&D employment. Demographic aging and increasingly fewer generations of young people, the dissolution of many R&D institutes and the reduction of R&D funding have led over time to the reduction of employment in the research field.

Table 4: The evolution of the researchers number

	1993	2000	2007	2014	2015	2016	2017	2018	2019	2020
RDI staff	73611	33892	28977	31391	31331	32232	32586	31933	31665	33189

Source: European Commission, PSF review of the Romanian R&I System, (2021).

The low attractiveness of the research system in Romania is also proven by the small number of foreign PhD students. According to the Report on the state of higher education in Romania in the academic year 2020-2021, a number of 34,447 students studied, and of these only 3%, respectively 970, followed doctoral study programs (Ministry of Education, 2022)

The sub-pillars that positively influenced Romania's position were the Knowledge Impact and Knowledge diffusion. The indicators that favourable influenced those sub-pillars were: Labour productivity growth, ISO 9001 quality certificates, ICT services exports (% total trade) and production and export complexity

Table 5: Romania's Strengths and Weaknesses

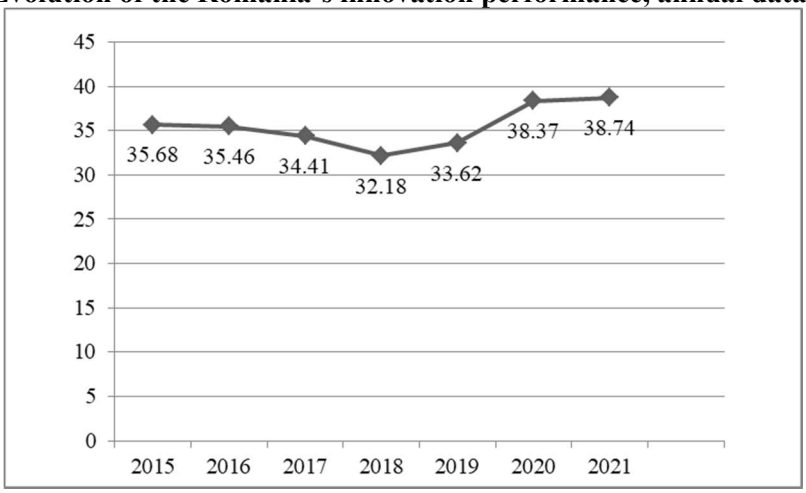
Strengths	Position in GII 2022	Weaknesses	Position in GII 2022
1.2.3 Cost of redundancy dismissal	1	1.1.2 Government effectiveness*	84
3.3.3 ISO 14001 environmental certificates	10	1.3.1 Policies for doing business	114
3.3.1 GDP/unit of energy use	19	2.2.1 Expenditure on education, % GDP	99
4.1.3Loans from microfinance institutions, % GDP	9	2.3.2 Gross expenditure on R&D, % GDP	64
4.3.1 Applied tariff rate, weighted avg., %	20	2.3.4 QS university ranking, top 3*	72
5.1.4 GERD financed by business, %	21	4.1.2 Domestic credit to private sector, % GDP	105
5.3.3 ICT services imports, % total trade	14	4.2.1 Market capitalization, % GDP	74
6.2.1 Labour productivity growth, %	4	4.2.3 Venture capital recipients, deals/bn. PPP$ GDP	81
6.2.4 ISO 9001 quality certificates/bn PPP$ GDP	17	4.2.4 Venture capital received, value, % GDP	95
6.2.5 High-tech manufacturing, %	23	5.2.1 University-industry R&D collaboration	82
6.3.4 ICT services exports, % total trade	11	5.2.4 Joint venture/strategic alliance deals/bn. PPP$ GDP	93

7.2.1 Cultural and creative services exports, % total trade	15	6.1.2 PCT patents by origin/bn. PPP$ GDP	79

Source: Own processing based on the Global Innovation Index 2022.

At the European level, according to the European Innovation Scoreboard 2021, Romania is an emerging innovator and occupies the last position in the EU in terms of innovation performance. As can be seen in Graph 1, the evolution of the global innovation index for Romania (compared to the European Union average) has not changed significantly over time. If in the period 2015-2016 the relative performance compared to the EU recorded the value of approximately 35%, in 2021 it recorded a modest progress reaching the value of 38.74%.

Graph 1: Evolution of the Romania's innovation performance, annual data 2015-2021

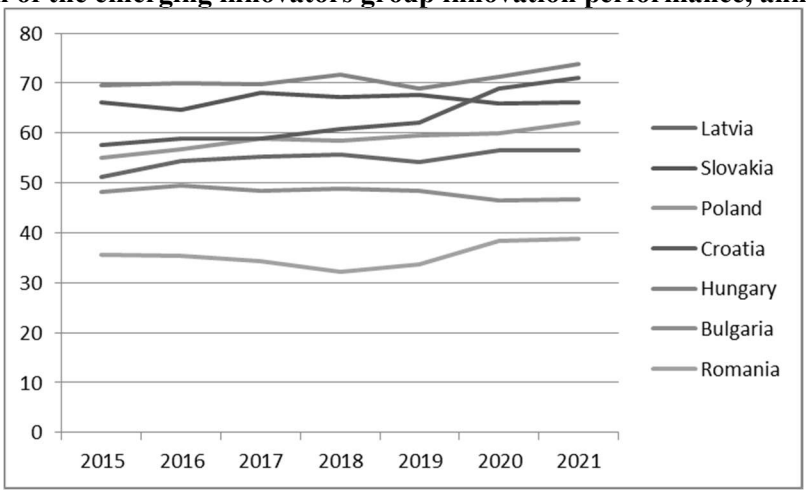


Source: Author based on data European Innovation Scoreboard (2021).

According to the latest edition of the European Innovation Scoreboard, among the top three indicators for which Romania recorded values close to or above the EU average are exports of high-tech goods, broadband internet penetration and venture capital investments. On the other hand, the list of weak points includes a much larger number of indicators, which reflects the poor level of innovation performance in Romania.

Romania has one of the lowest scores in Adjusted Research Excellence. Low integration in Space European Research Area (ERA) limits the connection to international R&D networks, with impact on the ability to attract dedicated funds from the research and innovation framework program (Horizon Europe) of the European Commission and producing results of international impact, publications and patents. The involvement of SMEs in innovation is marginal. The public-private collaboration, universities-companies is typical ad-hoc, while the scientific production resulting from these collaborations places Romania in the last places in the EU (Amcham, 2021).

Graph 2: Evolution of the emerging innovators group innovation performance, annual data 2015-2021

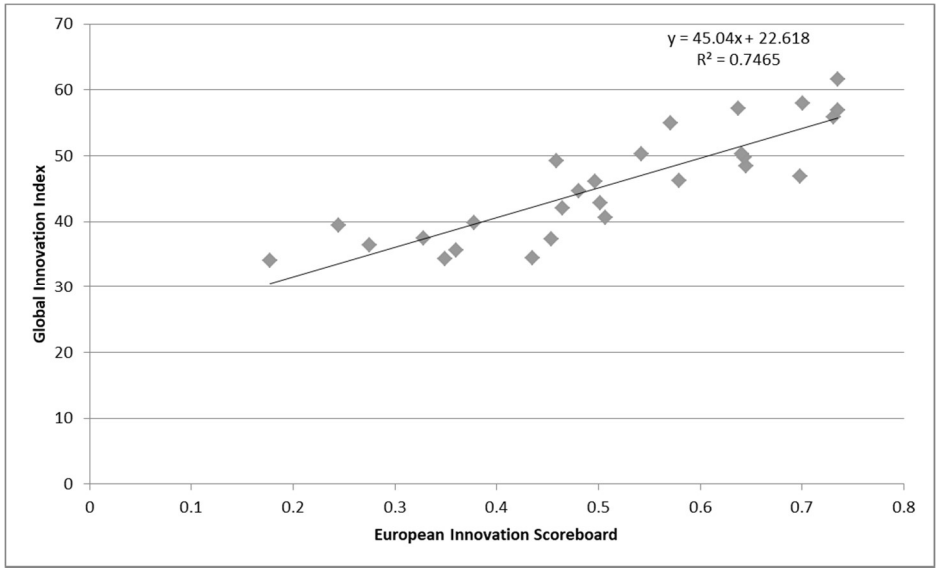


Source: Author based on data European Innovation Scoreboard (2021).

For emerging innovative countries, overall performance improved over the period 2014-2021. The leader of this group is Poland, and the last place is occupied by Romania. Three emerging innovators have registered strong increases in performance over time, Croatia, Poland and Latvia. For the rest of the countries, members of the emerging innovators group, innovation performance improved compared to 2014, but the increase was not significant. Only two states - Slovakia and Latvia - recorded decreases in performance in 2021 compared to 2020.

The positions occupied by the European countries, including Romania, at the global level in Global Innovation Index are correlated with the positions occupied at the European level in the European Innovation Scoreboard (European Commission, 2022).

Graph 3: The relationship between the European Innovation Scoreboard and Global Innovation Index 2022



Source: Author based on data Global Innovation Index and European Innovation Scoreboard 2022.

Based on the calculations, was obtained a coefficient of 0.74, which indicates a correlation between the European Innovation Scoreboard and the Global Innovation Index. This positive relationship is determined by the use of common indicators within the EIS and GII, as well as by the common purpose of the two tools to analyse innovation performance.

3. Conclusions

Romania is an emerging innovative country, with an innovation performance well below the EU average. The existing research-development-innovation system in Romania is not able to ensure overcoming the condition of a modest innovator, due to some of its weaknesses, among which the most important are: extremely low research and development expenses, under-financing, decreasing of the researchers number, the excessive priority given to fundamental research to the detriment of applied research, the lack of adequate incentives in favour of research and development, the lack of a periodic analysis of the real correlation between the needs of Romanian society and the priority programs as research direction within the national programs.

The position occupied by Romania in the Global Innovation Index is complemented by the position occupied in other world and European rankings, as follows:

- Romania ranks 19/133 in the list of the most complex countries in the world in the Economic Complexity Index ranking (Harvard, 2020).
- The 2019 Global Competitiveness Index of the World Economic Forum places Romania in 51st place out of 141 countries. The country ranks best in ICT adoption (32nd) and market size (41st), and worst in financial systems (86th), health (83rd), skills (72nd) and business dynamism (World Bank, 2020).
- Romania ranks 55th in the World Bank's Doing Business ranking, which evaluates the ease of doing business in 190 countries around the world. The country has gone through many reforms to make it easier to do business and is now closer to other EU member states in terms of scores for starting a business (EBRD, 2019).

- Romania has a below-average performance on all dimensions of the eco-innovation index (it ranks 25th out of the 27 member states). Eco-innovative outputs and activities are relatively at half of the EU average; the country is closer to the EU average in socio-economic outcomes (93%) and resource efficiency outcomes (81%) (European Commission, 2019).
- Romania ranks 26th out of 28 countries in the Digital Economy and Society Index (DESI) 2021. The country scores best in the Connectivity dimension and is well positioned in terms of ICT graduates (Human Capital), but digitization of the economy lags far behind. Regarding digital public services and the use of internet services, Romania has the worst performance in the EU (European Commission, 2021).

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